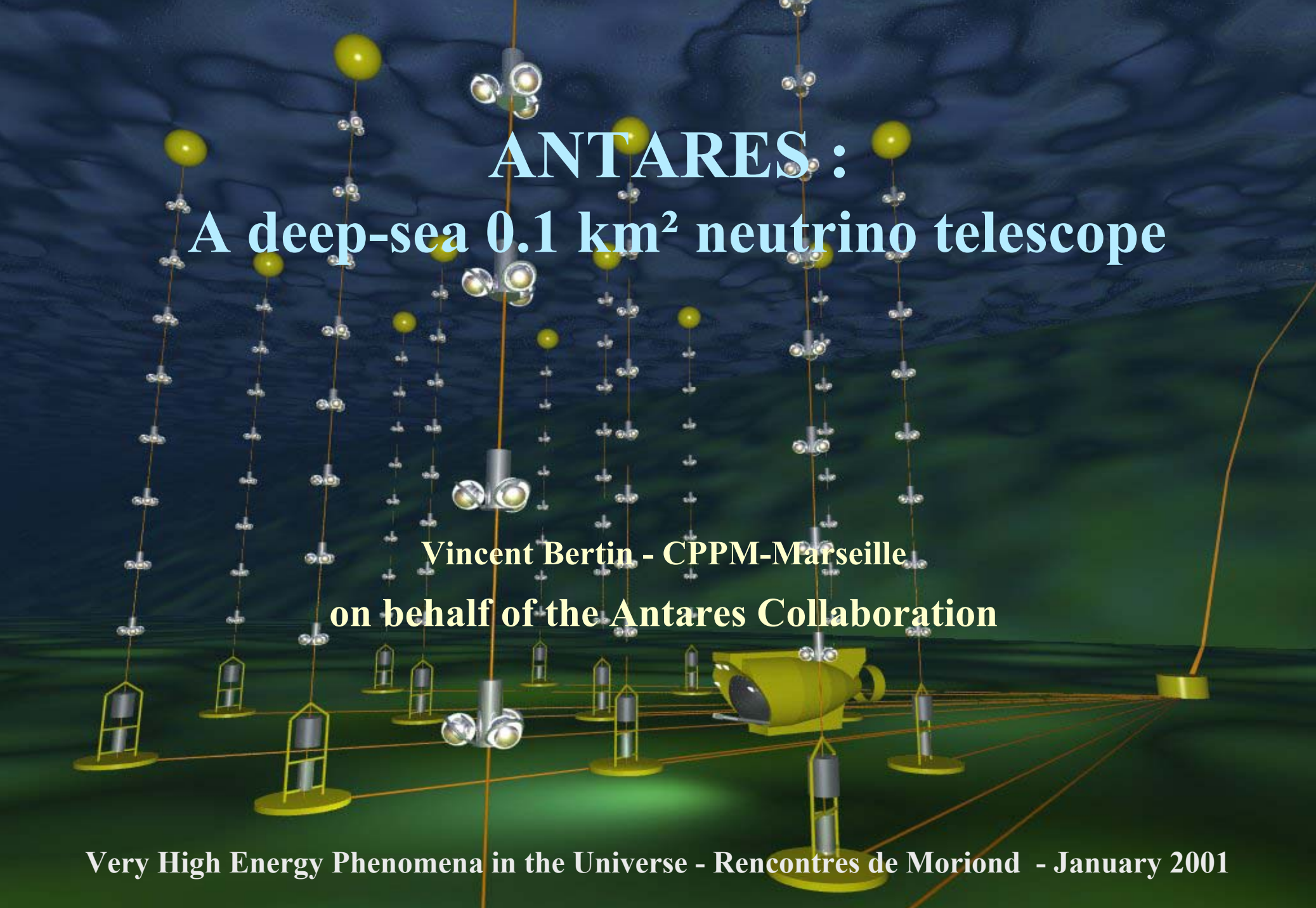
Antares: A Deep-Sea 0.1 km2 Neutrino Telescope

V. Bertin



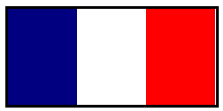
ANTARES :
A deep-sea 0.1 km² neutrino telescope

Vincent Bertin - CPPM-Marseille

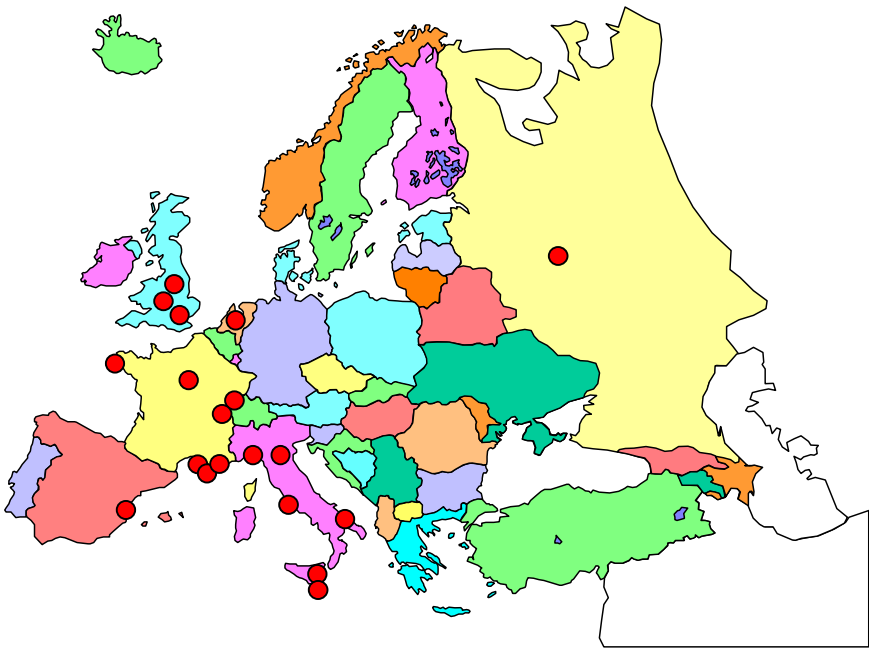
on behalf of the Antares Collaboration

Very High Energy Phenomena in the Universe - Rencontres de Moriond - January 2001

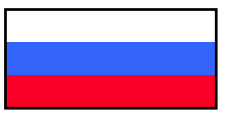
The ANTARES Collaboration



- CPPM, Marseille (IN2P3)
- DSM/DAPNIA, Saclay (CEA)
- IReS, Strasbourg
- Univ. of H.-A., Mulhouse
- C.O.M. Marseille
- IFREMER, Marseille/Brest
- IGRAP (INSU), Provence



- University of Oxford
- University of Sheffield



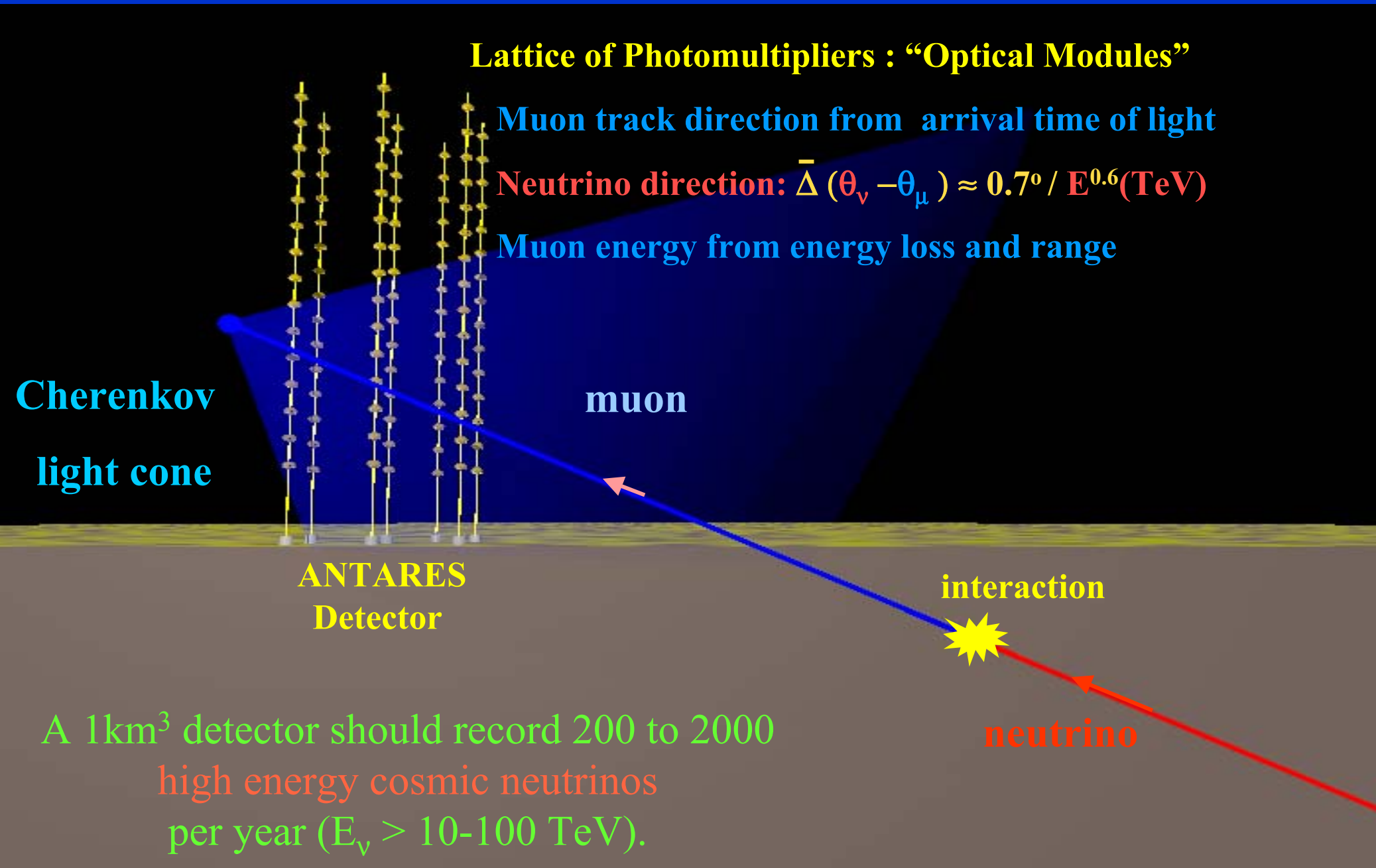
- ITEP, Moscow

- University of Bari
- University of Bologna
- University of Catania
- LNS – Catania
- University of Rome
- University of Genova

- NIKHEF, Amsterdam

- IFIC, Valencia

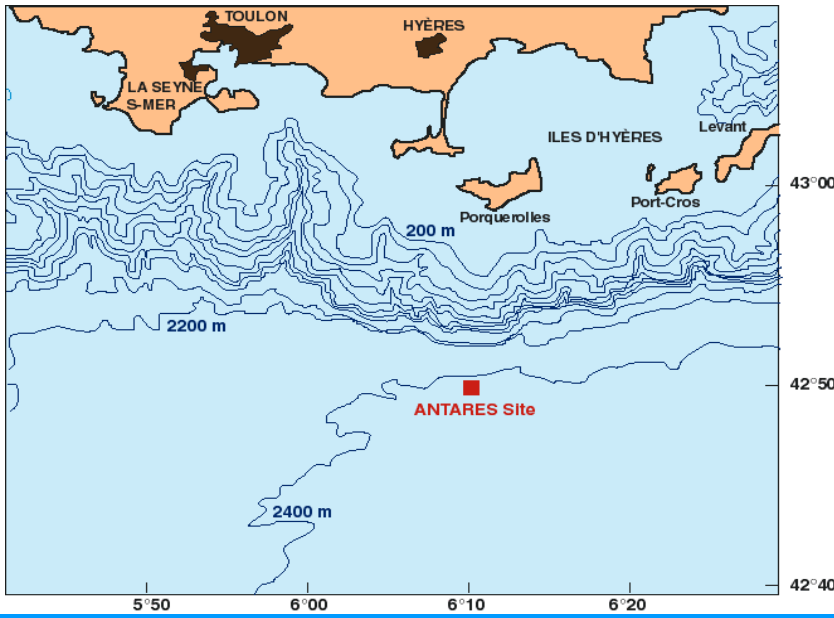
Detection Principle

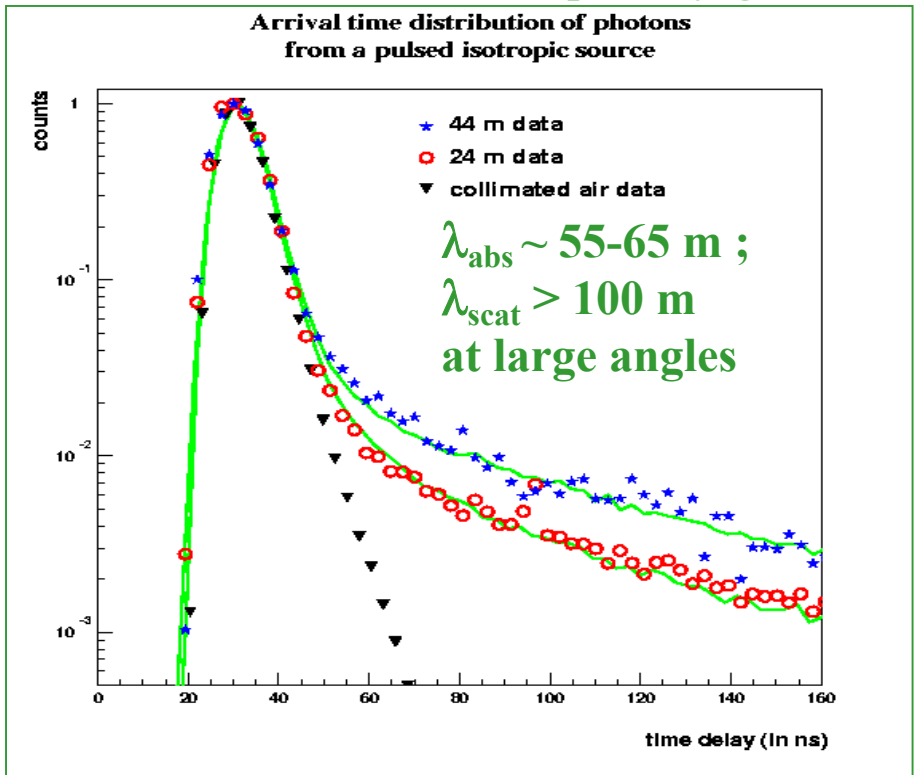


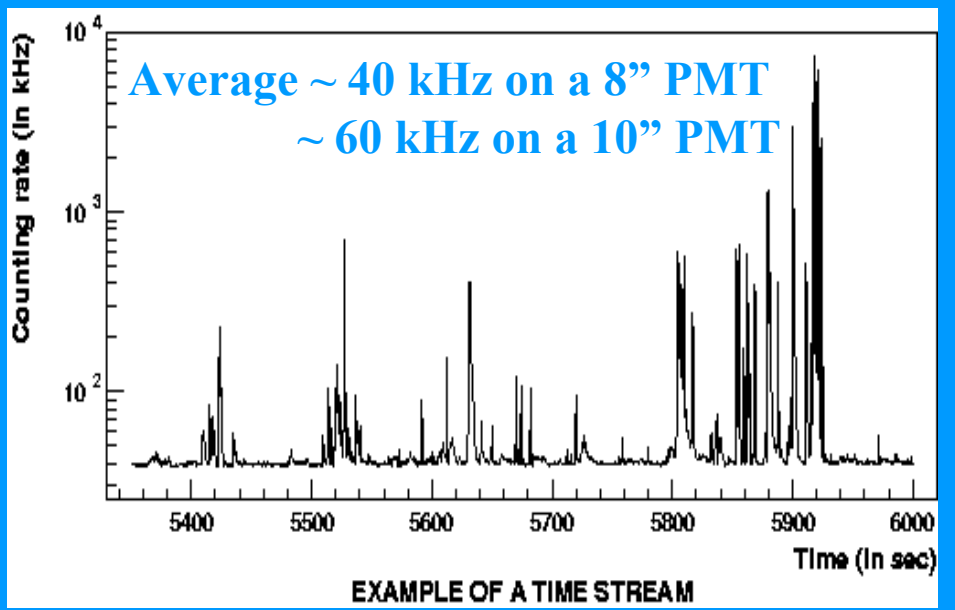
A $1km^3$ detector should record 200 to 2000 high energy cosmic neutrinos per year (E_ν > 10-100 TeV).

Phase I : Water properties measurements

- **Perform precise measurements of crucial environmental parameters :**
  - **In situ measurements on Antares site**
    (2400 m depth off French Mediterranean coast)
  - **Long term measurements of optical background** (^{40}K decays, bioluminescence) **and biofouling of Optical Modules**
  - **Measurement of water transparency @ 466 nm :**



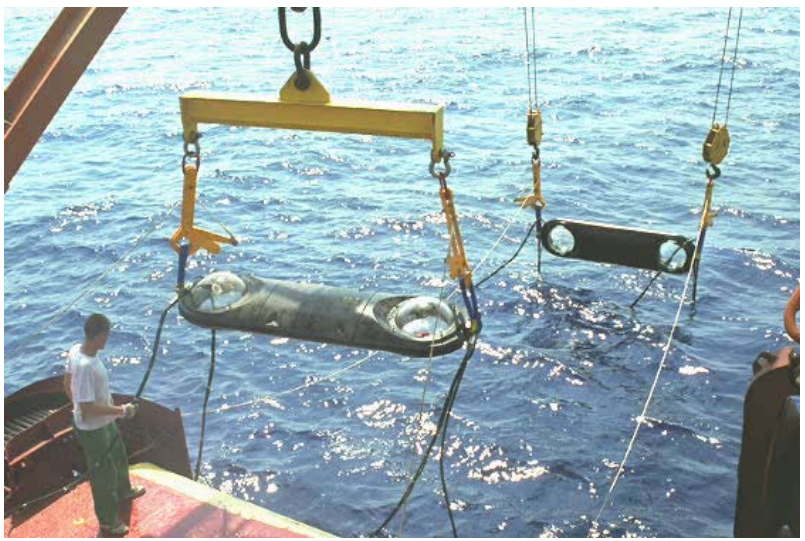


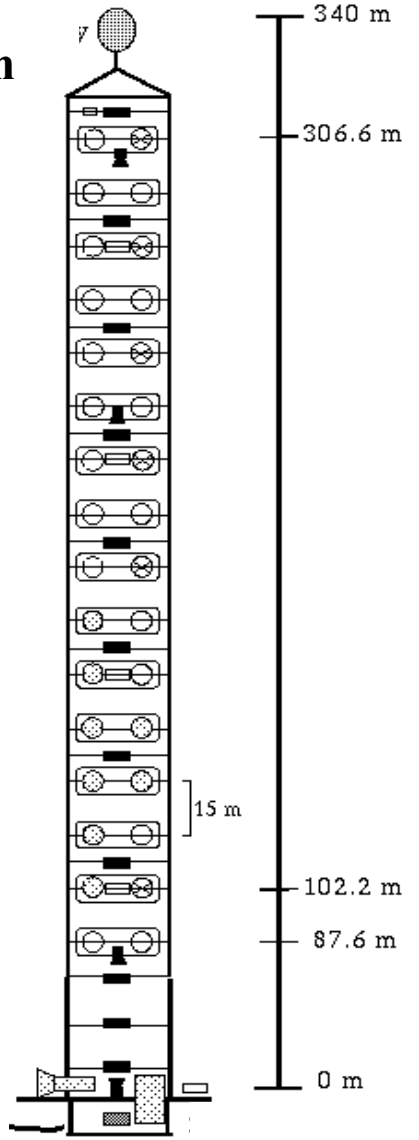


ANTARES Phase I : Demonstrator

- **First line of 350m high equipped with 16 pairs of Optical Modules**
  - **Summer 98 : successful deployment test at 2300m depth performed with Dynamical Positioning ship**
  - **December 99-June 00 : demonstrator equipped with 7 PMTs + acoustic positioning system linked to shore station by electro-optical cable**

NAUTILE



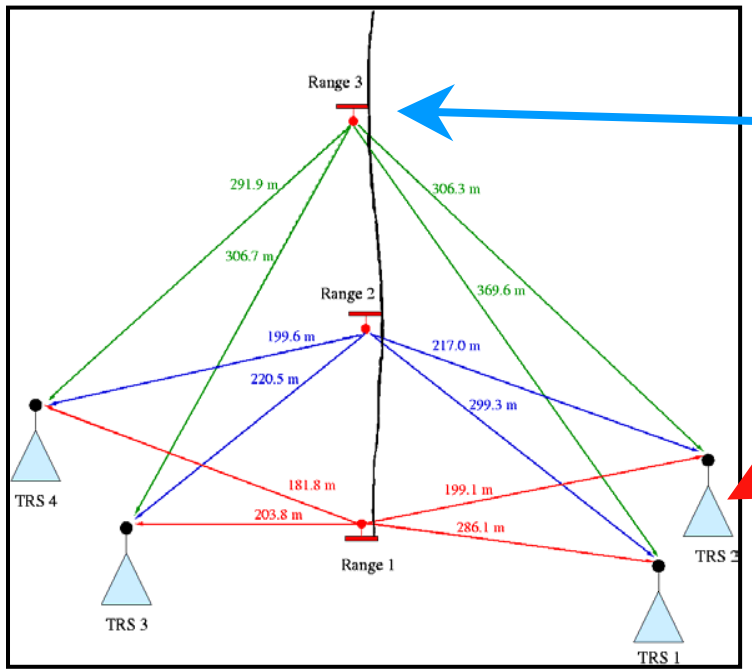


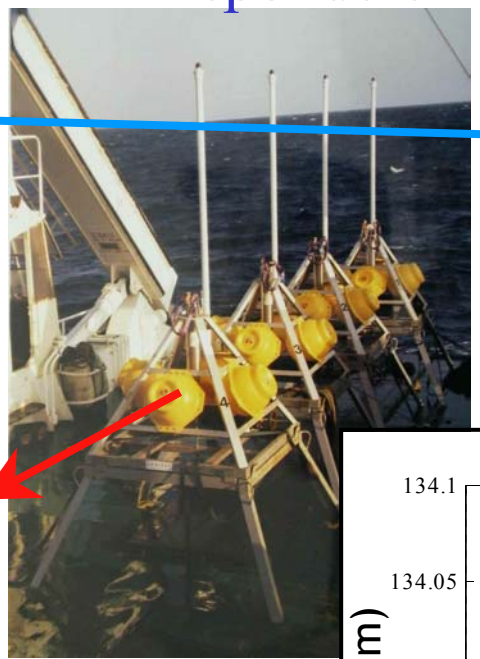
- **December 98 : successful undersea electrical connection test of detector anchor performed at 2400m depth by IFREMER submarine vehicle *Nautile***

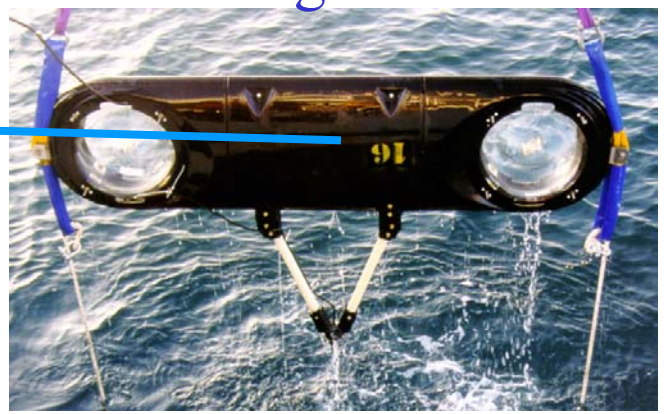
Acoustic positioning system

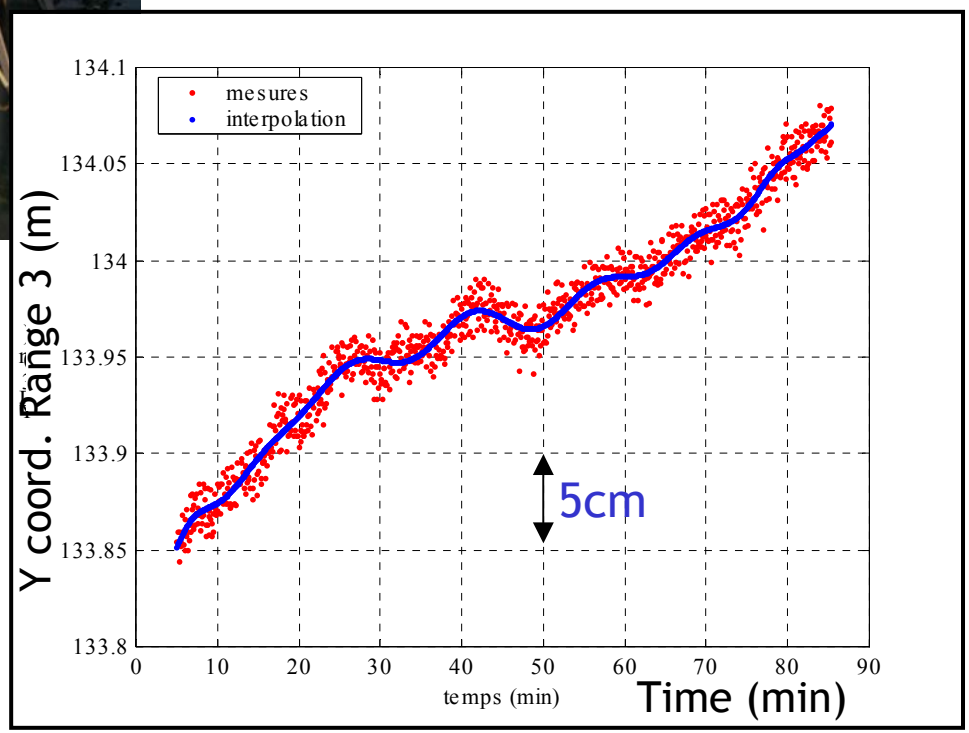
4 transponders

3 rangemeters







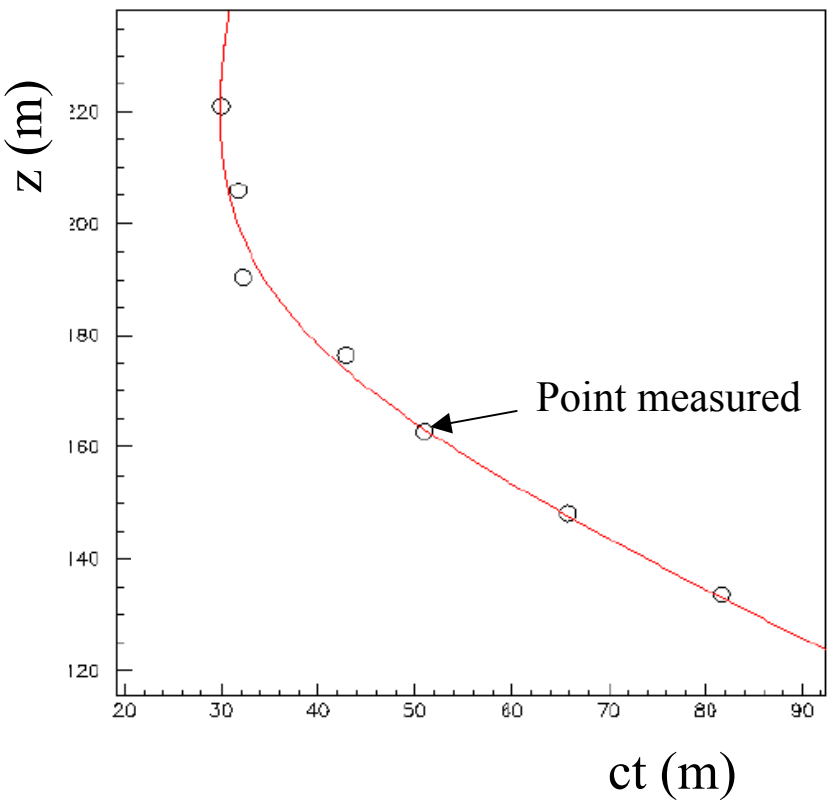


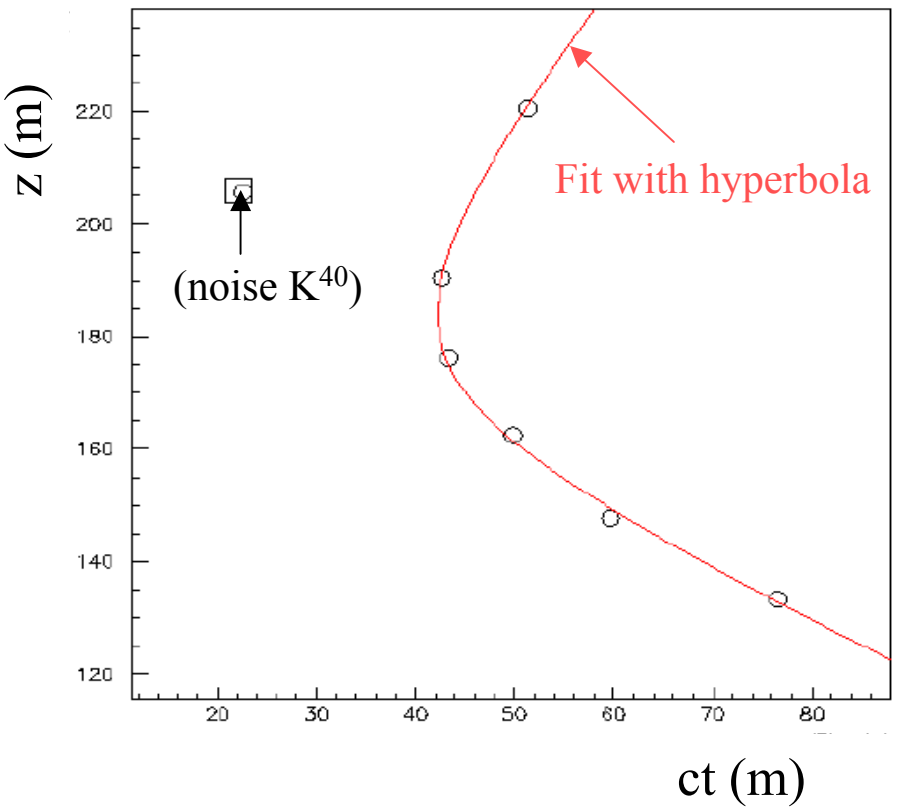
Devices	Accuracy (σ)
Inter-rangemeter	~ 1 cm
Inter-transponder	~ 1 cm
Rang.-Transpond.	≤ 3 cm

Triangulation allows ≤ 5 cm accuracy

Reconstruction of Atmospheric Muons

- More than 5×10^4 coincidences in all 7 PMTs have been recorded.
- Polar angle of down-going muons deduced from depth vs. time pattern.
- Hyperbolic fit (including multimuons).
- ^{40}K filtered out by the reconstruction software (see boxed hit in example).



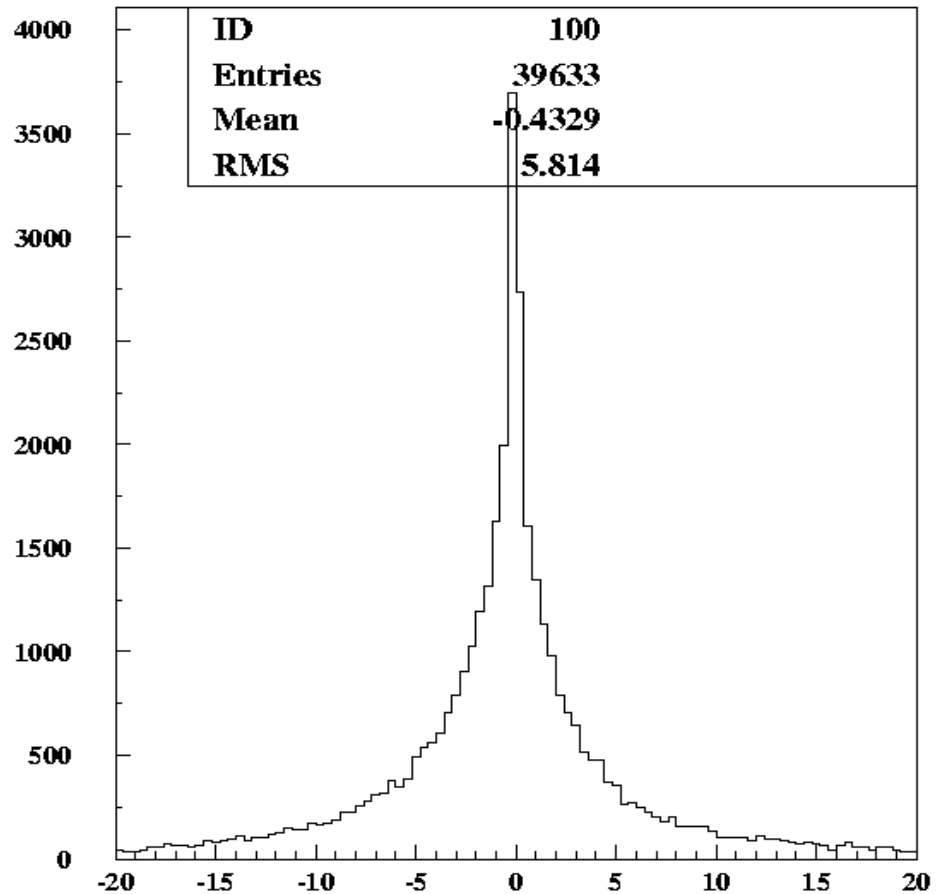


Reconstruction of Atmospheric Muons

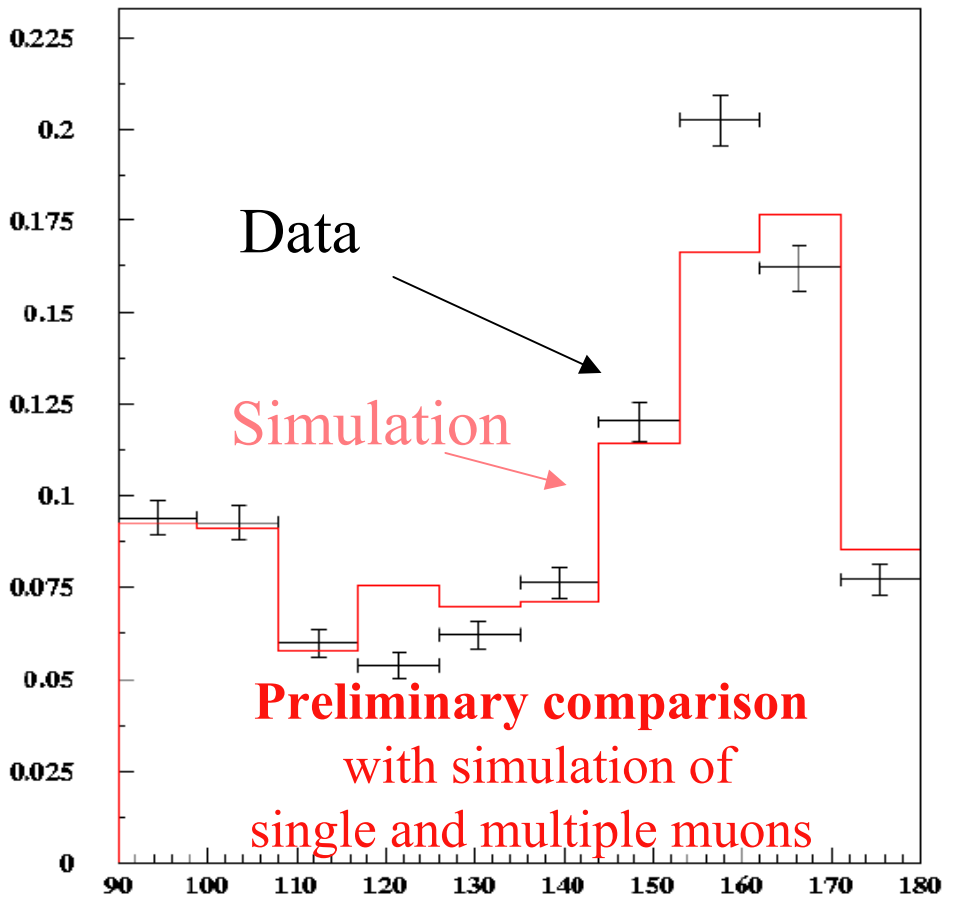
Over 50k 7-fold coincidences recorded

➡ **more than 1350 reconstructed events per day**

Δ(fit-point) in ns

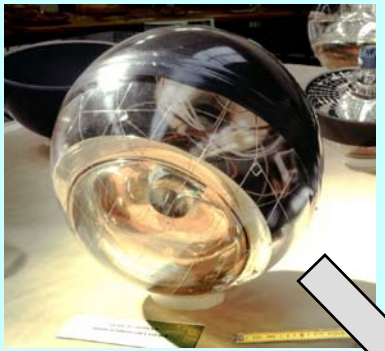


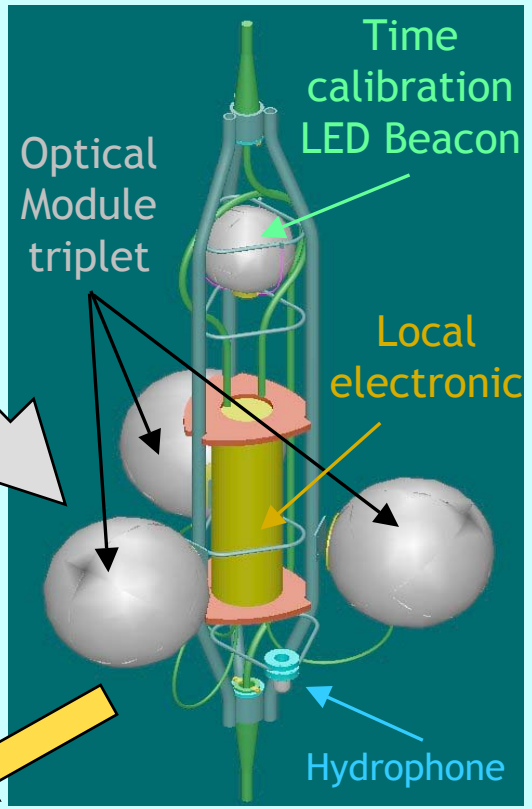
Angular Distribution



ANTARES Phase II : 0.1 km² Detector

10 strings : 900 PMTs in total
Detector to be deployed at ANTARES site by 2002 - 2004





Shore station

2500m

Electro-optic submarine cable ~ 40km

To be deployed in **Spring 2001**

~60m

float

300m active

~100m

anchor

Electronics containers

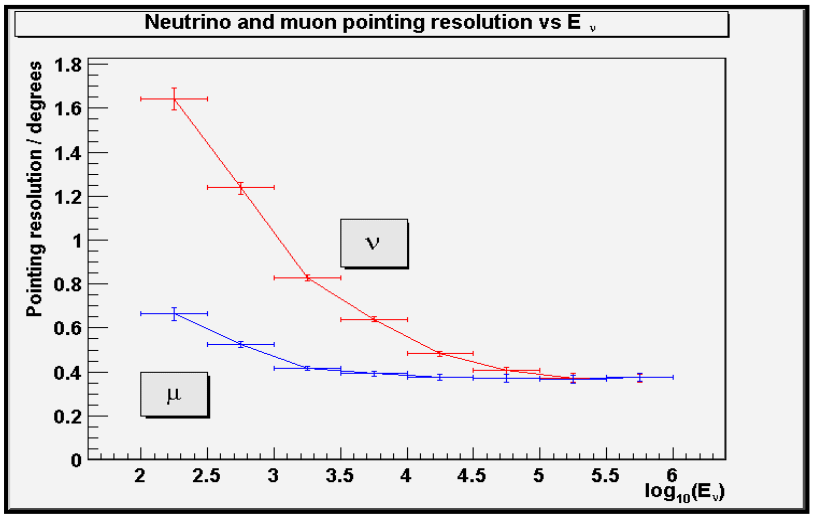
Readout cables

Junction box

Acoustic beacon

0.1 km² Detector : Expected performance

Angular resolution

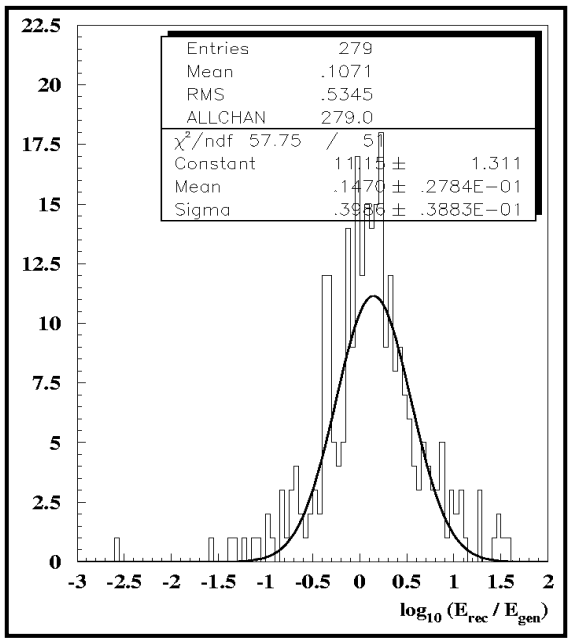


❖ Including effects of reconstruction and selection, PMT TTS, positioning, timing calibration accuracy and scattering.

❖ Below ~10 TeV angular error is dominated by ν-μ physical angle.

❖ Above ~10 TeV angular accuracy is better than 0.4° (reconstruction error).

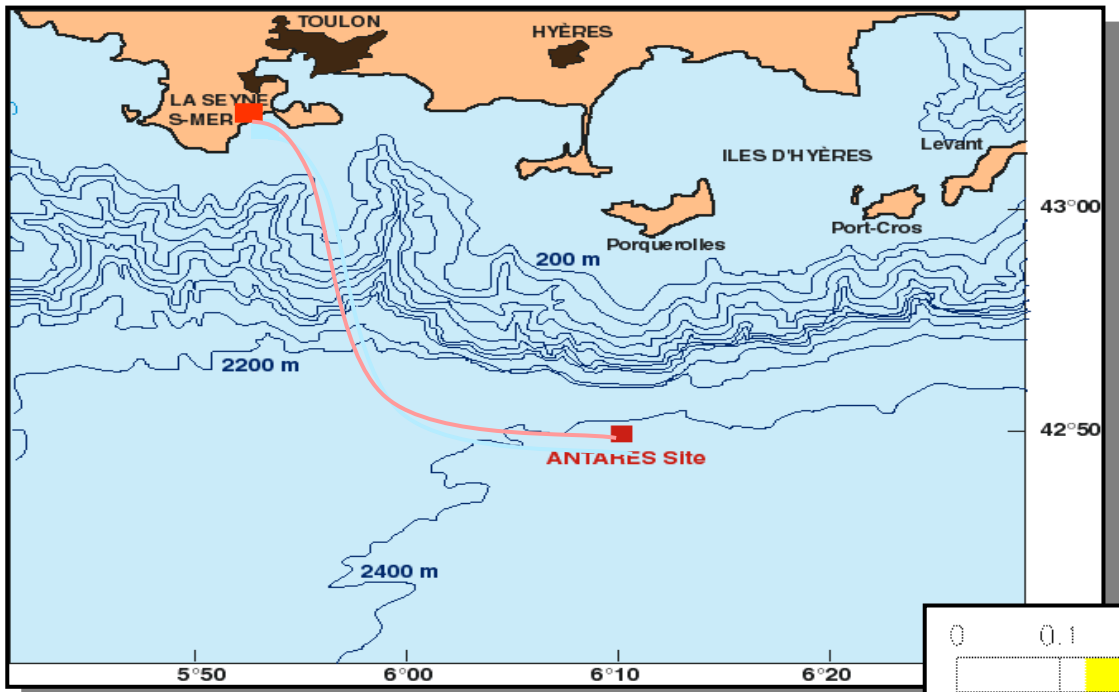
Energy resolution



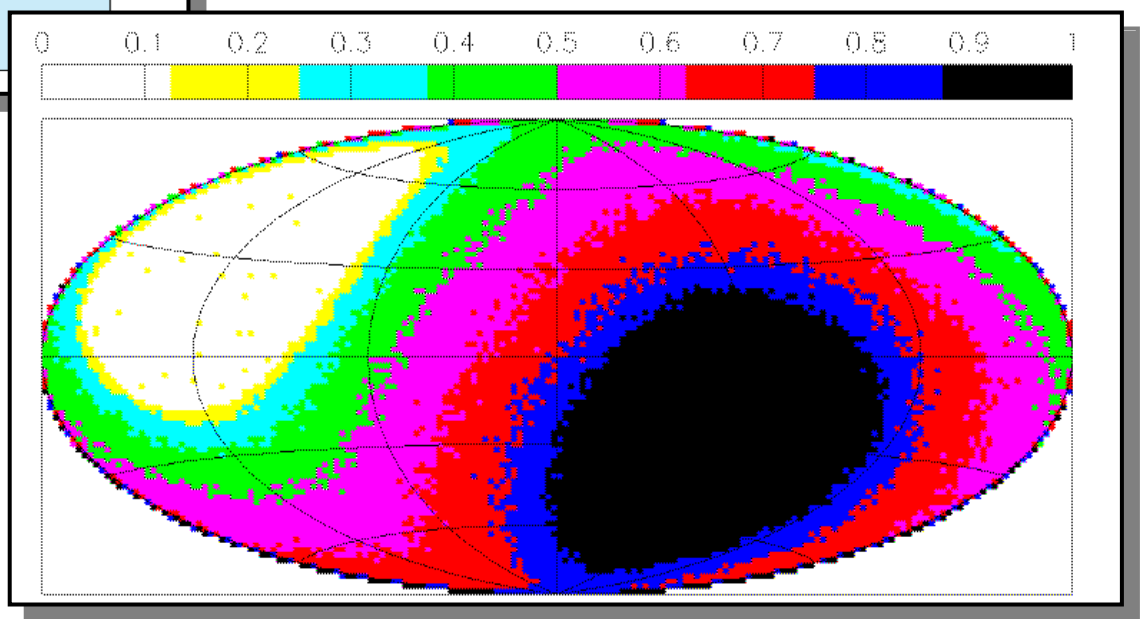
❖ $\sigma_E / E \approx 3$ (E >1 TeV)

❖ Below E ~ 100 GeV energy estimation via muon range measurement.

ANTARES 0.1 km² Detector Site



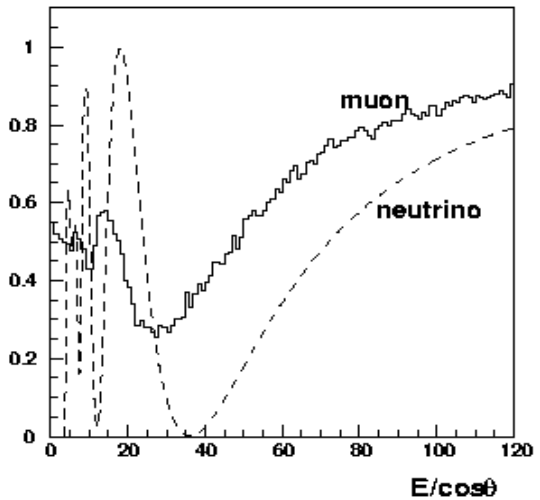
- 40 km SE of Toulon, Southern France (42º 50' N, 6º 10' E)
- Shore base at La Seyne-sur-Mer (excellent infrastructure)
- 2400 m below sea level

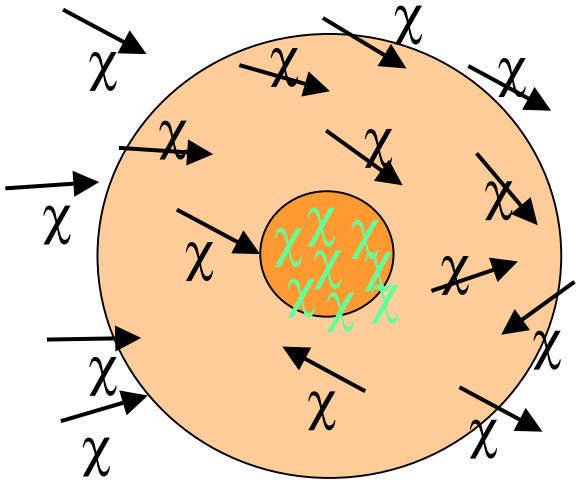


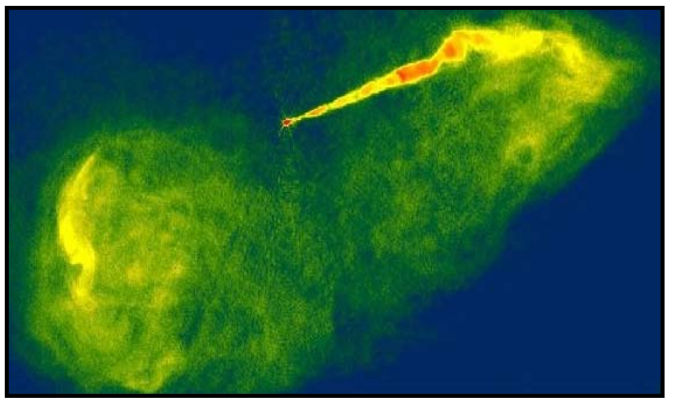
- 3.5π sr of the sky is covered
- 0.5π sr overlap with Amanda
- Galactic Centre surveyed

Scientific Programme

---> Energy --->







Low energy	Medium Energy	High energy
■ Neutrino oscillations via the modification in the energy spectrum due to observation of the first oscillation minimum	■ Search for neutralinos via their self-annihilation to products containing neutrinos at the centre of the Earth, Sun and Galaxy	■ Observation of neutrinos from (extra-)galactic sources such as GRB, AGN, Supernovae remnants, molecular clouds, etc.

Conclusions

ANTARES has made excellent progress over the past 4 years :

- Site environmental characterisation ⇒ **OK**
- Tests of marine technologies ⇒ **under control**
- Deployment and operation of Demonstrator String
- First down-going muons reconstructed
- Expanding Collaboration

ANTARES is well engaged in Phase II of its programme
by the design, the installation and the running
of a 10-strings 0.1 km² detector in 2002-2004

Major step forward towards **a km-scale neutrino telescope** in the Mediterranean Sea